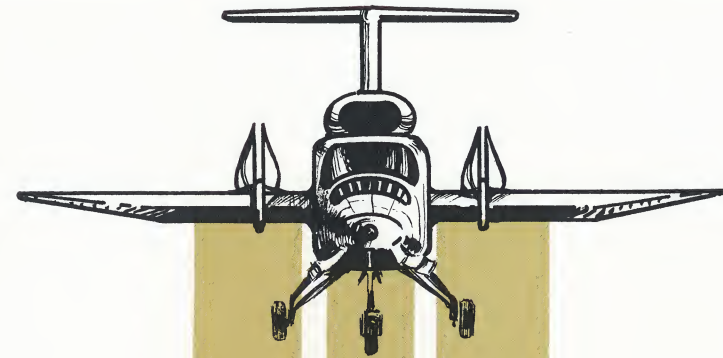




PROGRESS IN V/STOL PROPULSION

FLIGHT PROPULSION DIVISION

GENERAL  ELECTRIC

LYNN, MASSACHUSETTS/CINCINNATI, OHIO

General Electric's V/STOL propulsion developments lead the world. Nearly every V/STOL aircraft can be powered by General Electric engines.

No one V/STOL propulsion system can satisfy all missions and applications. Rotorcraft-helicopters, compounds, cranes—are tailored to meet specific mission requirements; fixed wing V/STOL aircraft—direct lift, lift fan, vectored thrust, augmented thrust, tilt-wing, tilt-prop—each can be economic and efficient when designed with the right propulsion system.

These V/STOL missions show the diversity of systems:

MISSION "A"—Carry six ton VTOL payload
200 n.mile combat radius,
3000 mile ferry range, VMax
350 knots, VCruise 300 knots.
Possible systems: Tilt-wing,
tilt-prop, lift/cruise fans.

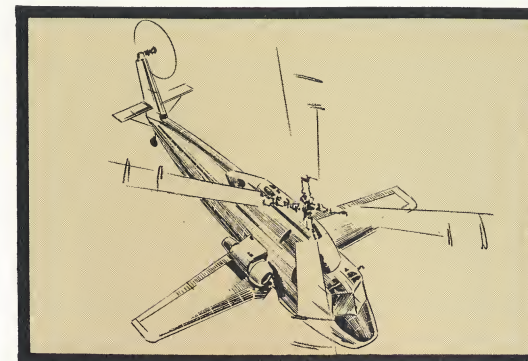
MISSION "B"—Carry twelve ton payload
60 n.mile radius, minimum
sustained hover 25 minutes,
VMax 100 knots.

Possible systems: Hot cycle
helicopter or heavy lift
crane.

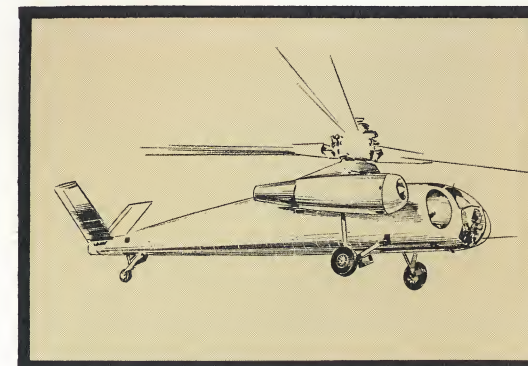
MISSION "C"—VMax 600 knots, five minute
hover, surveillance/strike
mission.

Possible systems: lift fan,
lift/cruise fan, vectored aug-
mented thrust, direct lift.

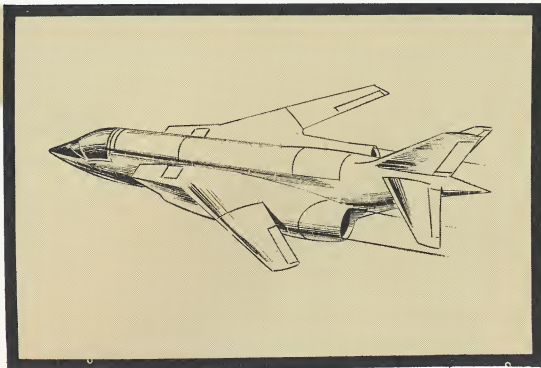
Most present day V/STOL aircraft are research vehicles; operational V/STOL aircraft which can be evaluated under simulated or actual field conditions will provide the best means of selecting a specific power system for each mission.



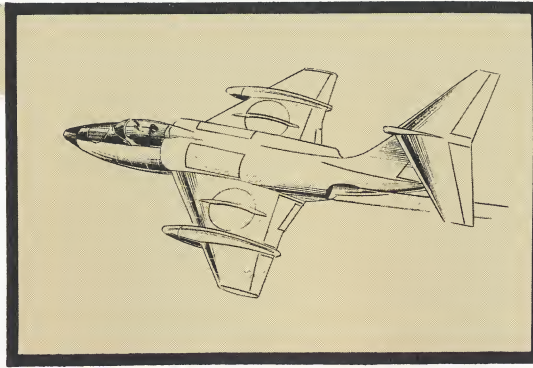
COMPOUND ROTORCRAFT—aircraft/helicopter configuration employs rotor, fixed wing, auxiliary propulsion.



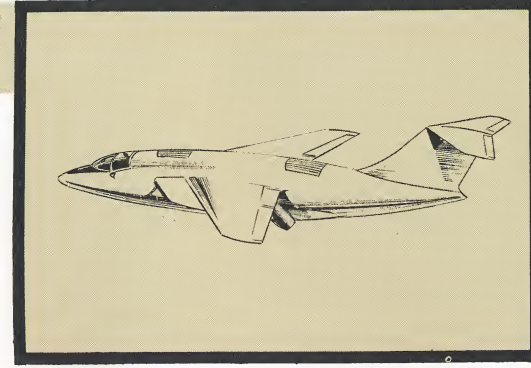
HOT CYCLE—hot gases ducted through rotor blades exhaust at blade tips to turn rotor.



VECTORED THRUST—horizontal mounted engine with vectoring devices used during vertical flight; same engine used for cruise.



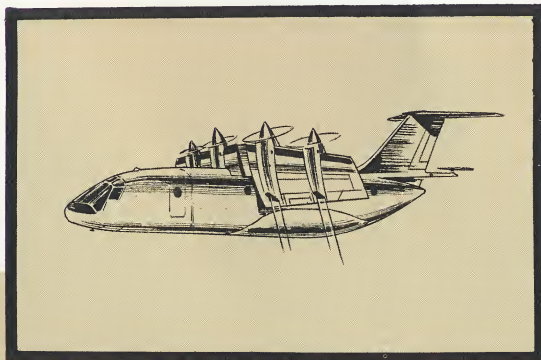
LIFT FANS—thrust from cruise engines is augmented nearly 300%—“Turbotip” fans provide vertical lift.



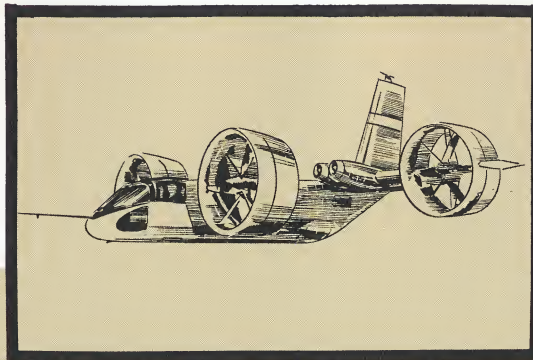
DIRECT LIFT—compact size for design and installation freedom. High thrust/unit volume. Cruise engine optimized.

V/STOL AIRCRAFT SYSTEMS . . . BY GENERAL ELECTRIC:

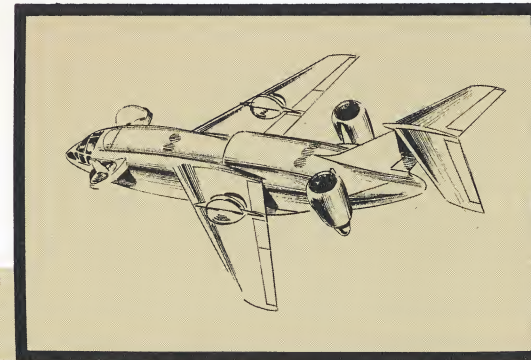
TILT WING—turboshaft engines interconnected by shaft; design allows full use of fuselage for cargo.



TILT PROP—interconnected shaft prevents assymetric thrust when operating on less than four engines.



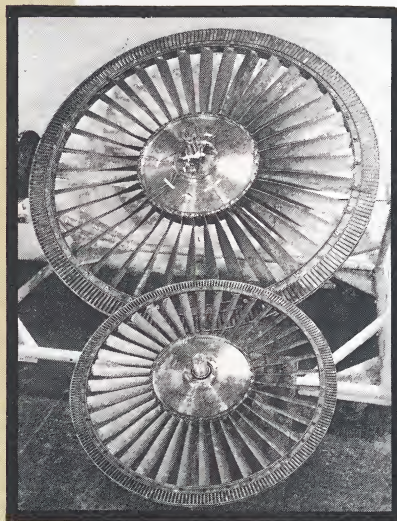
LIFT/CRUISE—combination of lift engines and/or lift fans with cruise engines/fans; both systems allow use of cruise engines during vertical flight.



General Electric "Turbotip" lift fans have proven themselves in flight test and four sizes are available in hardware. The 36 inch PF1 pitch fan, with a rated lift of 1850 pounds, has accumulated hundreds of trouble-free-flight and wind tunnel hours. Its companion, the 62.5 inch LF1, has also been flight-tested in more than 330 flights in the XV-5A. Rated lift of the LF1 is 6500 pounds. The next generation, the LF2, rated lift—7500 pounds, is proposed for growth versions of the XV-5A. The LF2 is running now. A larger fan, the LCF, rated lift—27,000 pounds, is the demonstrator prototype for a large, offset, vectorable fan for lift and cruise propulsion of a V/STOL transport.

Lift fan systems for V/STOL tactical and transport aircraft can be tailored to configuration requirements with any of the General Electric engines in this brochure. Fan development cost and time are significantly less than for a core engine. Features are:

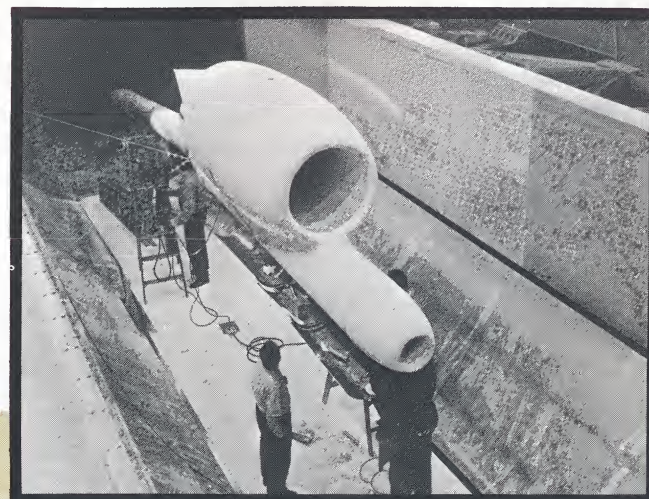
- Flight-proven V/STOL propulsion system.
- High-bypass, remote fan.
- Single stage fan and turbine.
- Low hover SFC.
- Low profile.
- Gas-coupled, simple interconnect.
- Low downwash velocity and temperature.
- Advanced fan development under contract.



The XV-5A aircraft has successfully demonstrated the lift fan system in more than 330 flights to date.

"TURBOTIP" LIFT

A 36 inch PF1 powered by a GE T58 has completed tests in a NASA/Langley wind tunnel to determine cruise fan performance.

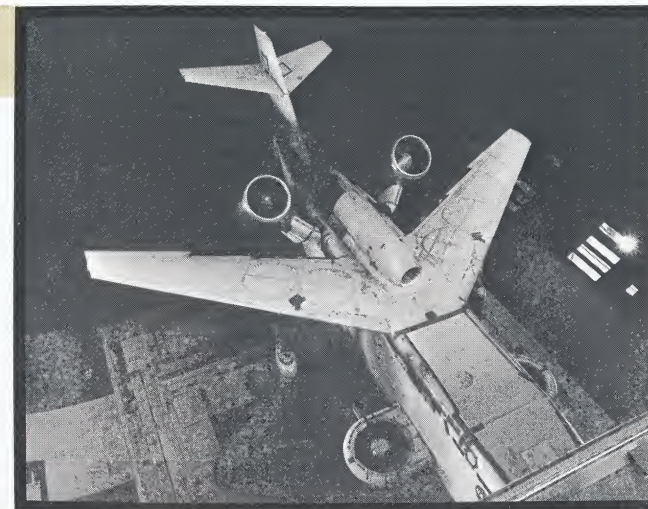
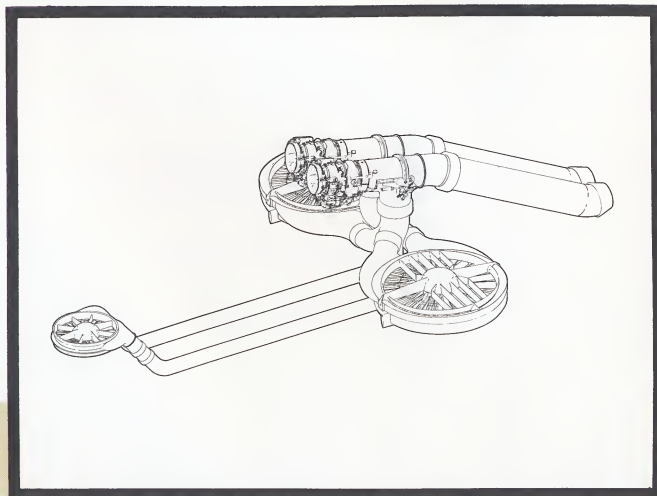




Six PF1 fans power a North American Aviation transport model in the NASA/Ames wind tunnel.

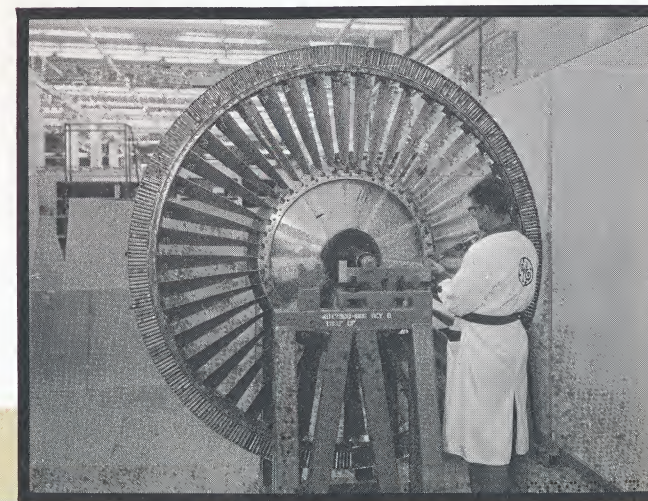
LIFT FAN APPLICATIONS AND TESTS:

The J85/LF1 system includes two diverter valves and three fans, cross-ducted for single-engine safety. System lift is 14,760 pounds.



A large V/STOL transport model with both lift fans and lift/cruise fans has been tested in the NASA/Ames wind tunnel.

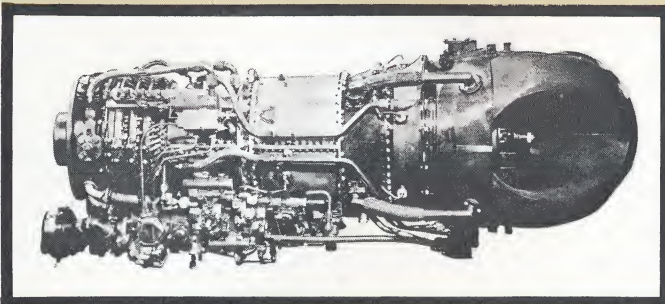
The 80 inch LCF is the forerunner of fans to power large V/STOL transports.



The General Electric T58 is a lightweight, compact powerplant which has been in production since 1959 for a variety of military and civilian applications. Current production models of the T58 turboshaft weigh 335 pounds and are rated at up to 1500 SHP with a specific fuel consumption (SFC) of 0.62.

More than 2500 T58 engines have been shipped for thirteen different aircraft applications. More than 2000 of these engines are now in service with the U.S. Air Force, U.S. Navy, U.S. Marine Corps, and the U.S. Coast Guard.

The CT58 commercial version of the engine is currently in service with three United States airlines and five foreign airlines.



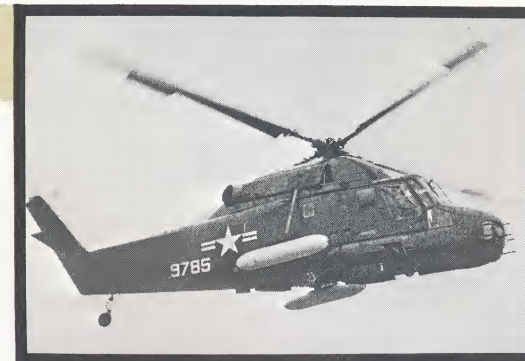
Total operating time for the GE T58 has now exceeded 1 million hours. Additional time is currently being logged at an annual rate of 300,000 hours.

Main features of the T58 include:

- Single stage, axial flow free power turbine.
- 2-stage, axial flow gas generator turbine.
- Short, small diameter annular combustor.
- 10-stage, axial flow compressor.
- Anti-iced inlet struts.
- Three-position exhaust.



Sikorsky SH-3A/D (twin T58's)—Navy anti-submarine warfare helicopter operational with the fleet.



Kaman UH-2A/B (single T58)—Navy utility helicopter operational with the fleet.

T58

Kaman UH-2C (twin T58's)—Navy utility helicopter.



Bell UH-1F (single T58)—Air Force utility helicopter.





Sikorsky CH-3C/E (twin T58's)—Air Force cargo transport helicopter; also in service as the Air Force HH-3E rescue helicopter.



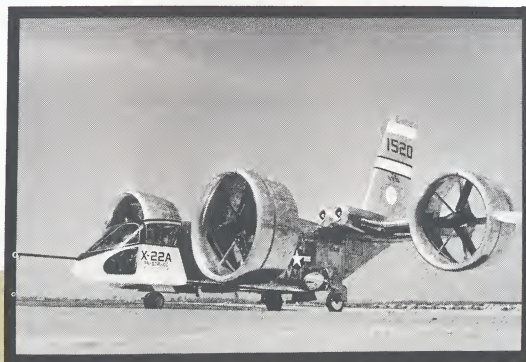
Sikorsky HH-52A (single T58)—Coast Guard search and rescue helicopter.

CURRENT MILITARY V/STOL AIRCRAFT POWERED BY GENERAL ELECTRIC T58 ENGINES:

Piasecki 16H-1A (single T58)—Army research compound rotorcraft; pusher prop in addition to rotor.



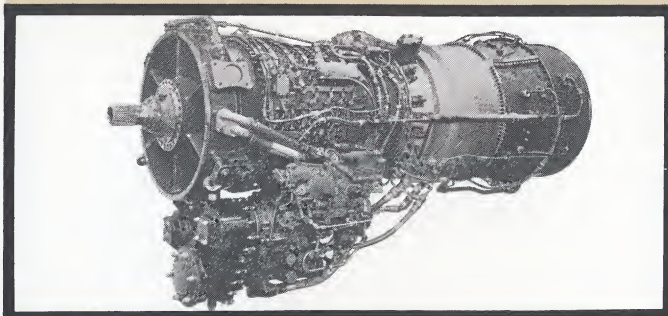
Bell X-22A (four T58 ducted props)—Tri-Service V/STOL research aircraft employing Variable Stability System.



Boeing-Vertol CH-46A (twin T58's)—Marine Corps medium assault transport helicopter; also in service with the Navy as UH-46 utility helicopter.

The General Electric T64 is a free turbine powerplant for conventional fixed wing, helicopters and V/STOL aircraft. It is available in turboshaft and turboprop configurations developing 2850 to 3080 HP. The engine has a fuel consumption comparable to piston engines of the same class over a broad power range and is capable of continuous operation through a wide range of attitudes required for the new generation of tilt-wing and tilt-prop V/STOL aircraft.

In addition to the U.S. Tri-Service use, the T64 is licensed for production in England, Japan, and Germany.



To assure that the T64 can accommodate the growth needs of existing applications and the requirements of future aircraft, programs are underway to increase the rating of the T64 to 3400 HP.

Main features of the T64 are:

- High pressure ratio compressor.
- Balance moment weight blades and buckets.
- Torque sensor on power shaft.
- Anti-iced front frame and inlet guide vanes.
- External nozzles and igniters.
- Short, small diameter, annular combustor.
- External fuel control, pumps, filters.
- Two stage gas generator turbine.

PROGRESS IN V/STOL PROPULSION

T64

AIRCRAFT NOW POWERED BY GENERAL ELECTRIC T64 ENGINES:



Hughes XV-9A (two T64's)—U.S. Army research helicopter with hot cycle.

Lockheed AH-56A (single T64)—Army Advanced Aerial Fire Support System (AAFSS) escort helicopter.





DeHavilland CV-7A (twin T64-10's)—Air Force fixed wing medium transport STOL aircraft under evaluation.



Sikorsky CH-53A (two T64's)—Marine Corps heavy assault helicopter; also being procured by the Air Force as the HH-53B with higher rated engines.

Fiat G222 (two T64-14's)—Italian Air Force STOL medium transport.

Vought-Hiller-Ryan XC-142A (four T64-1's)—Tri-Service VTOL tilt-wing transport undergoing operational evaluation.

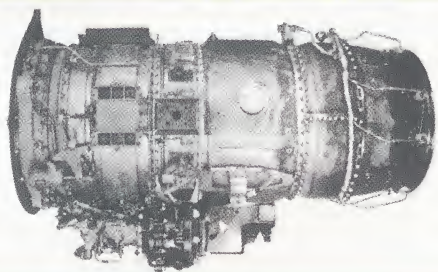


Shin Meiwa PX-S (four T64-10's)—Japanese STOL flying boat for Japan's Self Defense Force.



General Electric's dry J85 turbojet is a derivative of the J85 afterburning engine which offers the highest thrust to weight ratio of any engine available in its power class in the free world.

The dry J85 weighs only 387 pounds and produces a maximum thrust of 3015 pounds with an SFC of 1.00. Its small size (17.7 inches diameter and 45.4 inches length) and high thrust to weight (7.8) make it an attractive powerplant for many V/STOL systems.



J85

J85 features include:

- 8 stage, axial flow compressor.
- 2 stage axial flow turbine.
- Highest thrust-to-weight ratio of any production engine.
- Direct lift, vectored thrust, lift fan VTOL tested.

PROGRESS IN V/STOL PROPULSION

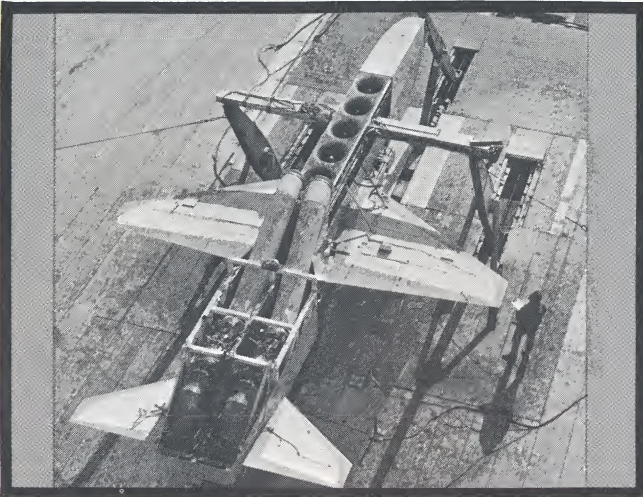


GE-Ryan XV-5A (J85/LF1 Lift Fan system)—Army research aircraft, also being flight-evaluated by U.S. Air Force for rescue service.

J85 POWERED V/STOL AIRCRAFT:

Lockheed XV-4B (six YJ85-19's)—Air Force VTOL research aircraft. A modification of the XV-4A is shown.





Northrop/NASA VTOL test vehicle (five YJ85-5's)—special research model designed to test problems encountered by future supersonic VTOL trainers and fighters.

Fairchild C-123H (twin J85-17 boost engines)—U.S. Air Force transport.

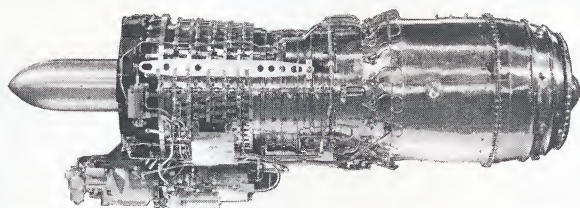


Martin SP-5B (single J85-2 boost engine)—U.S. Navy patrol seaplane.

Bell X-14A (two J85's)—uses deflected thrust propulsion system. Aircraft flying under NASA test program.



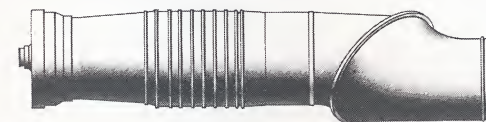
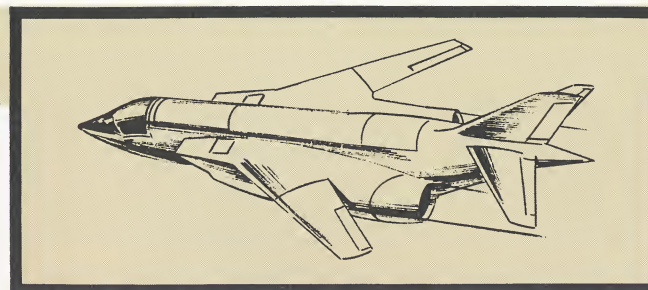
The General Electric GE1 "Building Block" approach utilizes one core engine as the "heart" of a family of advanced propulsion systems. Designed specifically for high gas horsepower and low SFC, the GE1 features:



- Application versatility—broad thrust range and diversified "add-on" components.
- Time and cost savings—the basic core engine is available in advance of components.
- Hardware standardization available for a variety of powerplants.
- Thrust size—spans a range of almost six times the basic core engine thrust.

Specifications are classified.

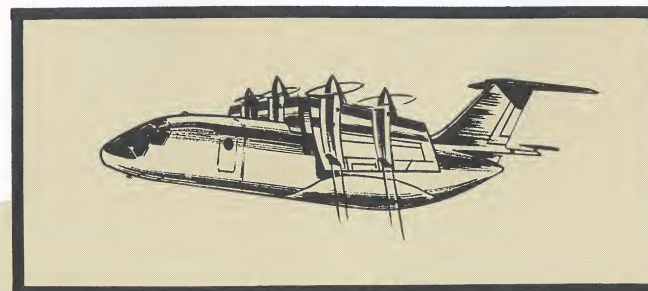
GE1



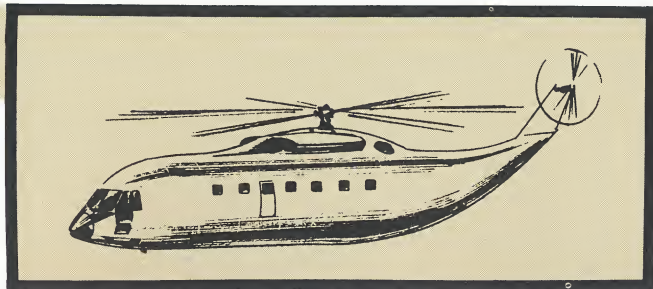
GE1 Augmented Vectored Turbofan—Sub/supersonic V/STOL fighter concept. Addition of a vectorable augmentor to a GE1 turbofan forms the lift/cruise propulsion system.

APPLICATIONS—GE1

GE1 Turboprop—Tilt-wing V/STOL transport. High turbine discharge pressure and temperature provide a high level of gas horsepower per pound of airflow, making shaft applications of the GE1 practicable.

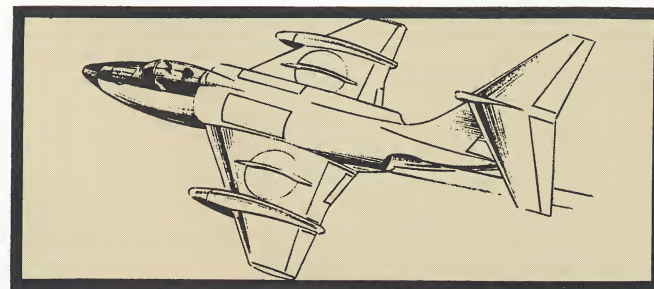
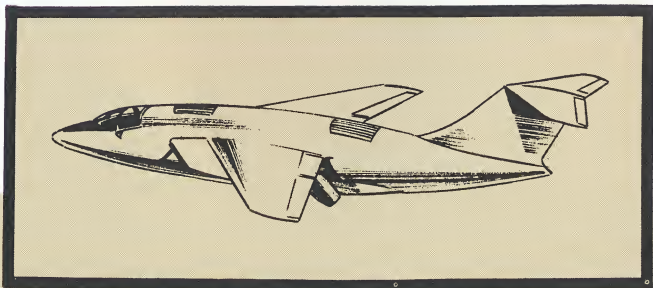


PROGRESS IN V/STOL PROPULSION

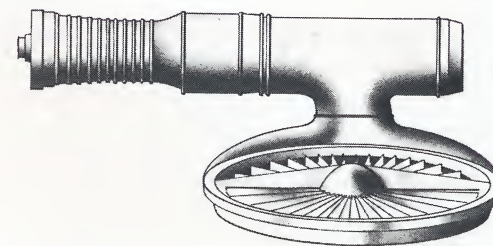


GE1 Turboshaft—Heavy crane. Powerplant suited for higher weight class helicopters.

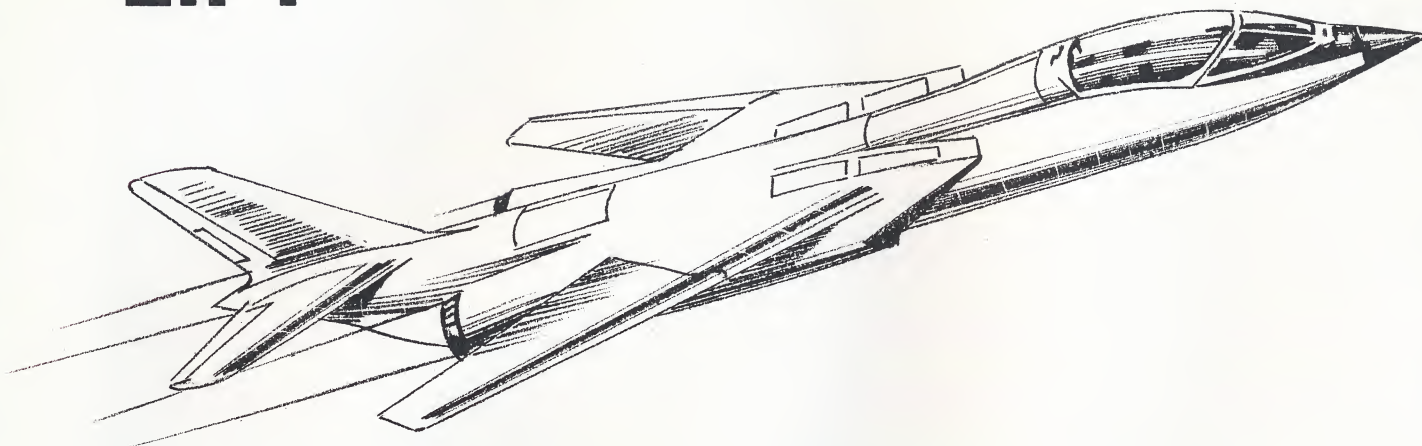
GE1 Non-augmented Vectored Turbojet—Subsonic V/STOL fighter. Addition of vectoring devices to non-augmented GE1 turbojet or turbofan engines, coupled with direct lift engines, produces an attractive V/STOL powerplant.



GE1 Lift Fan—Subsonic V/STOL fighter. Basic GE1 core engine, because of its high power per pound of airflow, is uniquely suited for use with lift fans. Fan-in-wing, fan-in-fuselage, and folding fans are design options.



DIRECT LIFT



RESEARCH FOR HIGH MACH V/STOL AIRCRAFT

General Electric is currently working under military contracts to develop components and advanced technology applicable to future direct lift engines. Technology from these research programs is being considered for future V/STOL requirements, especially in the design of high performance sub/supersonic fighter aircraft.

Reduction of overall engine size and weight, increasing performance, simplifying maintenance and controls—these are among the objectives of this program.

Specifications and other details are classified.

PROGRESS IN V/STOL PROPULSION

Propulsion development is the pacing factor leading to operational V/STOL aircraft. Lighter materials,

advanced processes, and promising component research are being combined by General Electric to de-

velop new V/STOL power systems which will surpass the current successful General Electric engines and systems.

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